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<b>UTILITY PATENT APPLICATION TRANSMITTAL</b>  <small>(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))</small>	Attorney Docket No. <u>RCA 90,297</u>
	First Inventor or Application Identifier <u>Voessing, et al.</u>
	Title <u>Method and Encoder for Bit-Rate*</u>
	Express Mail Label No. _____

<b>APPLICATION ELEMENTS</b> <small>See MPEP chapter 600 concerning utility patent application contents.</small>		<b>ADDRESS TO:</b> Assistant Commissioner for Patents Box Patent Application Washington, DC 20231																																	
1. <input checked="" type="checkbox"/> Fee Transmittal Form (e.g., PTO/SB/17) <small>(Submit an original and a duplicate for fee processing)</small> 2. <input checked="" type="checkbox"/> Specification [Total Pages <u>7</u> ] <small>(preferred arrangement set forth below)</small> - Descriptive title of the invention - Cross References to Related Applications - Statement Regarding Fed sponsored R & D - Reference to Microfiche Appendix - Background of the invention - Brief Summary of the invention - Brief Description of the Drawings (if filed) - Detailed Description - Claim(s) - Abstract of the Disclosure 3. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets <u>1</u> ] 4. Oath or Declaration [Total Pages <u>2</u> ] a. <input checked="" type="checkbox"/> Newly executed (original or copy) b. <input type="checkbox"/> Copy from a prior application (37 C.F.R. § 1.63(d)) <small>(for continuation/divisional with Box 16 completed)</small> i. <input type="checkbox"/> <b>DELETION OF INVENTOR(S)</b> Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).	5. <input type="checkbox"/> Microfiche Computer Program (Appendix) 6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary) a. <input type="checkbox"/> Computer Readable Copy b. <input type="checkbox"/> Paper Copy (identical to computer copy) c. <input type="checkbox"/> Statement verifying identity of above copies																																		
<b>ACCOMPANYING APPLICATION PARTS</b> 7. <input checked="" type="checkbox"/> Assignment Papers (cover sheet & document(s)) 8. <input type="checkbox"/> 37 C.F.R. § 3.73(b) Statement (when there is an assignee) <input checked="" type="checkbox"/> Power of Attorney 9. <input type="checkbox"/> English Translation Document (if applicable) 10. <input checked="" type="checkbox"/> Information Disclosure Statement (IDS)/PTO-1449 [4] Copies of IDS Citations 11. <input type="checkbox"/> Preliminary Amendment 12. <input checked="" type="checkbox"/> Return Receipt Postcard (MPEP 503) (Should be specifically itemized) 13. <input type="checkbox"/> Small Entity Statement(s) <input type="checkbox"/> Statement filed in prior application, Status still proper and desired (PTO/SB/09-12) 14. <input checked="" type="checkbox"/> Certified Copy of Priority Document(s) (if foreign priority is claimed) 15. <input checked="" type="checkbox"/> Other: <u>Search Report and Priority Document</u>																																			
16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment: <input type="checkbox"/> Continuation <input type="checkbox"/> Divisional <input type="checkbox"/> Continuation-in-part (CIP) of prior application No: _____ Prior application information: Examiner _____ Group / Art Unit: _____ <b>For CONTINUATION or DIVISIONAL APPS only:</b> The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.																																			
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<table border="1"> <tr> <td>Name</td> <td colspan="3">Joseph S. Tripoli</td> </tr> <tr> <td></td> <td colspan="3">Thomson Multimedia Licensing Inc.</td> </tr> <tr> <td>Address</td> <td colspan="3">Patent Operation</td> </tr> <tr> <td></td> <td colspan="3">Two Independence Way, P. O. Box 5312</td> </tr> <tr> <td>City</td> <td>Princeton</td> <td>State</td> <td>NJ</td> </tr> <tr> <td></td> <td></td> <td>Zip Code</td> <td>08543-5312</td> </tr> <tr> <td>Country</td> <td>USA</td> <td>Telephone</td> <td>609/734-</td> </tr> <tr> <td></td> <td></td> <td>Fax</td> <td>609/734-9700</td> </tr> </table>				Name	Joseph S. Tripoli				Thomson Multimedia Licensing Inc.			Address	Patent Operation				Two Independence Way, P. O. Box 5312			City	Princeton	State	NJ			Zip Code	08543-5312	Country	USA	Telephone	609/734-			Fax	609/734-9700
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\*Saving Encoding of Audio or Signals

5 The invention relates to a method and an encoder for bit-rate saving encoding of audio signals, especially for encoding of audio signals according to MPEG 1 Audio Layer II.

## BACKGROUND OF THE INVENTION

The MPEG 1 Audio standard as specified in ISO/IEC 11172-3 defines three operational modes known as Layers I, II and 15 III. Each Layer offers increased compression but also increased encoding complexity, whereby downward compatibility is guaranteed: Therefore, a Layer II decoder can also read a Layer I data stream but no Layer III data stream. Also a Layer III decoder can decode all MPEG 1 20 Audio bit streams, i. e. Layer I to III.

MPEG 1 Audio data compression is based on subband coding. The audio signal is split into 32 subbands of equal width. A quantization is performed using a psychoacoustic model that is adapted to the masking behaviour of the human hearing. Each subband signal is quantized in such a way that the quantization noise introduced by the coding will not exceed the masking curve for that subband. After quantization the samples build - together with the scale factors and further coding information - a frame structure for transmission.

In ISO/IEC 11172-3 two independent psychoacoustic models are defined which can be adapted to any Layer. The output

from these psychoacoustic models is a set of Signal-to-Masking Ratios,  $SMR_n$ , for every subband  $n$ .

In order to calculate the  $SMR_n$  for the psychoacoustic  
5 model 2 a Fast Fourier Transformation (FFT) with a length  
of 1024 samples is used, which has to run two times per  
channel, i. e. four times for a stereo channel.

#### 10 SUMMARY OF THE INVENTION

The invention is based on the object of specifying a  
method for bit-rate saving encoding of audio signals using  
a psychoacoustical model with reduced computing power.  
15 This object is achieved by means of the method specified  
in claim 1.

It is a further object of the invention to disclose an  
encoder which utilises the inventive method. This object  
20 is achieved by the apparatus disclosed in claim 6.

The invention is based upon the following realization. On  
the one hand a FFT is a special discrete Fourier  
Transformation for which the number of samples has to be a  
25 power of two, e.g. 1024 samples. However, on the other  
hand the frame length of MPEG 1 Audio Layer II is 1152  
samples which is no power of two. This results in the two  
runs per channel of the FFT according to prior art.

30 The known formula for a discrete Fourier Transformation,  
which calculates for  $L$  elements of a data series  $z(n)$  the  
corresponding  $L$  frequency values  $F(m)$ ,

$$F(m) = \frac{1}{L} \sum_{n=0}^{L-1} z(n) \exp(-j2\pi \frac{mn}{L})$$

can be transformed first into  $k$  partial sums with  $M$  summands each

$$F(m) = \frac{1}{L} \sum_{i=0}^{k-1} \left[ \sum_{n=0}^{M-1} z(kn+i) \exp(-j2\pi \frac{m(kn+i)}{L}) \right]$$

5

and finally with  $L=kM$  and splitting the exponential function into

$$F(m) = \frac{1}{k} \sum_{i=0}^{k-1} \left[ \frac{1}{M} \sum_{n=0}^{M-1} z(kn+i) \exp(-j2\pi \frac{mn}{L}) \right] \exp(-j2\pi \frac{mi}{L}).$$

10

Therefore, using  $k$  subtransformations with a length of  $M=2^N$  allow time effective calculation with Fast Fourier Transformations, even if  $L$  is not a power of two.

15 In principle, the method for bit-rate saving encoding of  
audio signals using a psychoacoustic model, wherein a  
Fourier Transformation is performed for calculation of a  
minimum masking threshold and wherein L samples of the  
audio signal are arranged in a frame for transmission,  
20 consists in the fact that the Fourier Transformation is  
performed with a length of L samples by calculating k  
subtransformations over  $2^N$  samples with  $k \cdot 2^N = L$  and fitting  
together the results of the k subtransformations.

25 In this way, the duplicate run per channel is avoided without loss of information or introduction of errors. Therefore, the computing power is reduced nearly to the half. This is especially important for the implementation on digital signal processors to run in real time.

30

Although the inventive method is especially advantageous, if the number  $k$  of subtransformations is not a power of 2,

the use of the invention is not restricted to such values of  $k$ .

Advantageously, before fitting together the results of the  
5 k subtransformations, these are multiplied with phase  
correction factors.

In an advantageous manner, the Fourier Transformation is performed within the algorithm for the psychoacoustic model 2 of MPEG I Audio Layer II, wherein the frame length L is 1152 samples.

In an advantageous development  $k=9$  subtransformations with a length of  $M=2^N = 128$  samples are calculated.

## BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention are described with  
20 reference to the figure, which shows schematically the use  
of the subtransformations.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

25 Although the encoder is not standardized in ISO/IEC 11172-3, certain means for encoding such as the estimation of the masking threshold or quantization are commonly used and therefore are not described in detail in the

30 following. First of all PCM audio samples with a sampling frequency of 32, 44.1 or 48 kHz (or with half sample frequencies of 16, 22.05 or 24 kHz) are fed into the encoder. A mapping is performed to create a filtered and subsampled representation of the input audio stream in the

35 form of so-called subband samples. Each subband signal is

quantized in such a way that the quantization noise introduced by the coding will not exceed the masking curve for that subband. In order to control the quantization a psychoacoustic model is used to calculate the new bit allocation, for MPEG 1 Audio Layer II for three blocks totaling 36 subband samples corresponding to 1152 input PCM samples. The calculation is based on the Signal-to-Masking Ratios,  $SMR_n$ , for all the subbands, which makes it necessary to determine for each subband the maximum signal level and the minimum masking threshold. The minimum masking threshold is derived by using the inventive method which is schematically shown in Fig. 1. After windowing the input PCM samples, samples corresponding to a frame F1 are split and fed to nine subtransformation ST1, ..., ST9. Each subtransformation has a length of 128 samples ( $9 \times 128 = 1152$ ) which is the seventh power of 2 ( $2^7 = 128$ ). After Fast Fourier Transformations of the partial signals the results of the nine subtransformations are multiplied with phase correction factors, symbolized by multiplier units M1, ..., M9. The phase corrected data are combined, symbolized by adder unit A and then used for the further calculation of the psychoacoustic model. The same method is applied to the following audio samples corresponding to frames F2, F3 etc.

The invention can advantageously be used for encoding of audio signals according to MPEG 1 Audio Layer 2, but also applies to the encoding of any other kind of digital data.

The invention can be implemented in any kind of encoders which can be used e.g. for Digital Audio Broadcast (DAB), Cable and satellite radio/TV or digital recording devices like DVD-VRs etc.

Patent Claims

WHAT IS CLAIMED, IS

1. Method for bit-rate saving encoding of audio signals  
5 using a psychoacoustic model, comprising the steps of:  
performing a Fourier Transformation with a length  
of L samples for calculation of a minimum masking  
threshold by calculating k subtransformations over  $2^N$   
samples with  $k \cdot 2^N = L$ ;  
10 fitting together the results of the k  
subtransformations;  
arranging L samples of the audio signal in a frame  
for transmission.
- 15 2. Method according to claim 1, **wherein** the number k of  
subtransformations is not a power of 2.
3. Method according to claim 1, **wherein** before fitting  
together the results of the k subtransformations, these  
20 are multiplied with phase correction factors.
4. Method according to any of claims 1, **wherein** the  
Fourier Transformation is performed within the  
algorithm for the psychoacoustic model 2 of MPEG I  
25 Audio Layer II and wherein the frame length L is 1152  
samples.
5. Method according to claim 4, **wherein**  $k=9$   
subtransformations with a length of  $M=2^N = 128$  samples  
30 are calculated.
6. Encoder for performing the method according to claim 1.

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MPEG 1 Audio data compression is based on subband coding. A quantization is performed using a psychoacoustic model which is adapted to the masking behaviour of the human hearing. Each subband signal is quantized in such a way that the quantization noise introduced by the coding will not exceed the masking curve for that subband. In ISO/IEC 11172-3 two independent psychoacoustic models are defined. The output from these psychoacoustic models is a set of Signal-to-Masking Ratios,  $SMR_n$ , for every subband  $n$ . In order to calculate the  $SMR_n$  for the psychoacoustic model according to the invention a Fast Fourier Transformation is performed with a length of  $L=1152$  samples by calculating  $k$  subtransformations over  $2^N$  samples with  $k \cdot 2^N = L$  and fitting together the results of the  $k$  subtransformations.



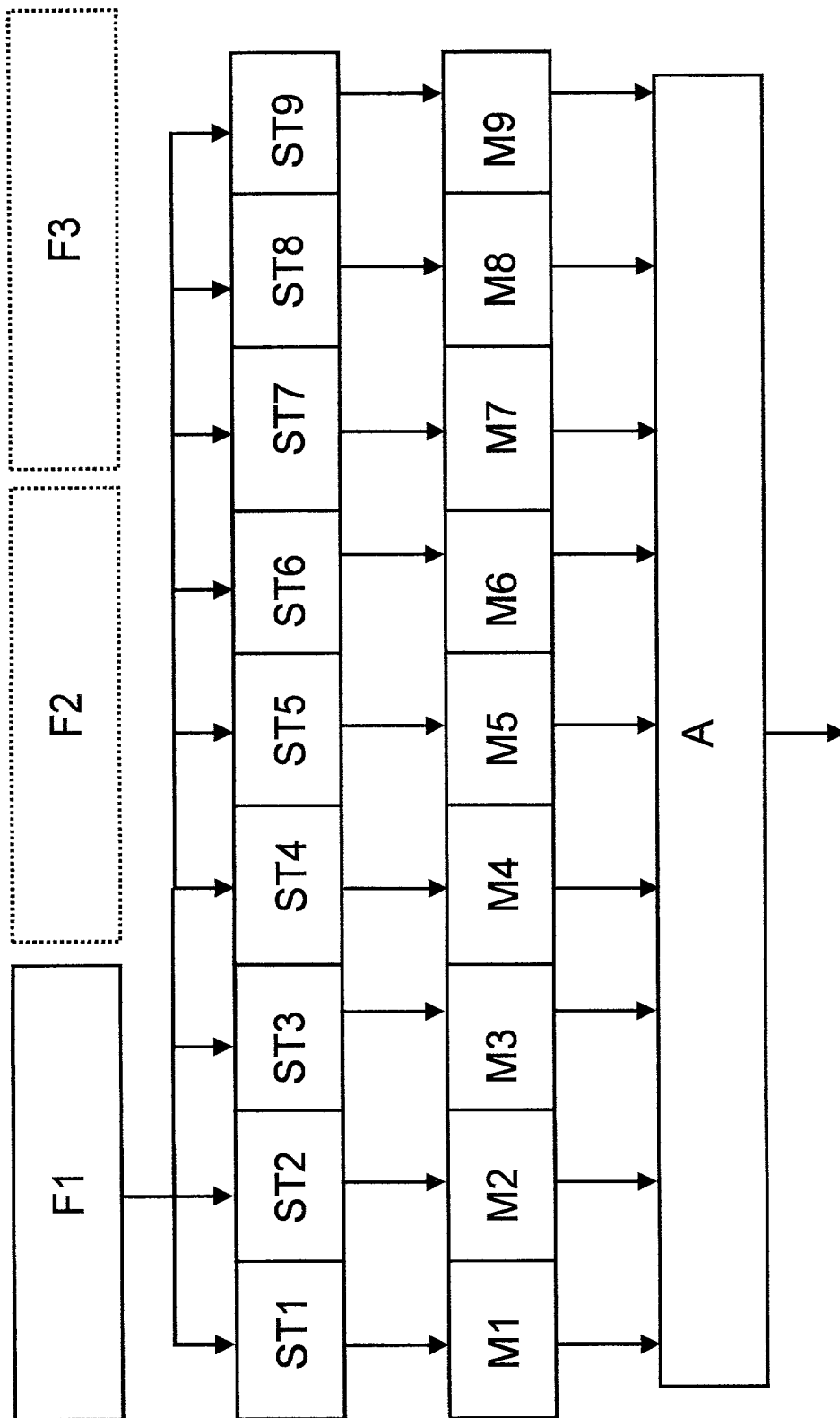


Fig. 1



Signature:  Date: 26<sup>th</sup> day of April, 2000.

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